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Finding Them Before They Find Us: Solving the Emerging Infectious Disease Crisis

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Abstract

The human population grows daily, it's on the move, and it's carving a deep technological footprint on our planet. We alter landscapes and perturb ecosystems, inserting ourselves and other species into novel regions of the world, leading to potentially irreversible changes in the biosphere. This is not news. More than 75 years ago, Charles Elton, one of the founders of modern ecology, wrote, "We must make no mistake; we are seeing one of the greatest historical convulsions in the world's fauna and flora." We are also in the midst of a public health and epidemiological crisis. Climate change alters movements and geographic distributions for myriad species. Transporting people and goods carries countless pathogens of humans and our domestic animals and crops hourly around the globe. Previously isolated species come into sudden contact. Pathogens and parasites encounter hosts with no resistance and no time to evolve any. This is also not news—maladies rare or unknown four or five decades ago, like HIV and Ebola, West Nile Virus and Avian Influenza, and now SARS-CoV-2—have become commonplace. In such a world—this world—the only world we will ever know—events like these are ongoing. Scarcely a week passes without news of a new pathogen trading up to a human host. This is the crisis of Emerging Infectious Disease (EID). We must mount an all-out effort to discover and document the species—pathogens and hosts—on our globe before it is too late to cope effectively with the crisis.

Chancellor Perlman, colleagues, honored guests, fellow alumni. I thank you for this singular honor.

I came to the University of Nebraska nearly 40 years ago because it was the university farthest from home that offered me economic independence through an athletic scholarship. As is so often the case for those privileged to live in this state for any length of time, I got much more from that deal than I imagined possible.

I was in the first freshman class of Centennial College, an audacious experiment in stimulating fertile young minds, many of them the first members of their families to attend university. Centennial College gave its students permission to be creative and smart, and rewarded them for seeing with the clear eyes of youth.

And I had fine mentors. Foremost among them was Professor Mary Lou Pritchard, who showed me the gateway

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Daniel R. Brooks, evolutionary biologist, parasitologist, tropical biodiversity specialist, University of Nebraska–Lincoln alumnus, and senior research fellow in the Harold W. Manter Laboratory of Parasitology, was presented with an honorary doctor of science degree and gave the commencement address for UNL at the fall semester graduation ceremony in December 2007. This article is his commencement address, which was the beginning of many works published on the subjects of emerging infectious disease (EID) and the linkages with global warming, climate change, and biodiversity.

Daniel R. Brooks shown after imaging landscape diversity in the Sharga Gobi during the last field-year of the National Science Foundation–funded Mongolian Vertebrate Parasite Project. Photo by Scott L. Gardner.

to the research for which you honor me today. She encouraged me to think outside the box, not to follow the crowd, to pursue new and controversial ideas. I am honored she is here today. Mary Lou, my love, respect, and gratitude know no bounds.

Some years ago, an undergraduate in one of my classes became interested in a method of analysis I had developed twenty years earlier. Within two months, she replaced it with a better one. That day, I took my place beside those mentors who took a chance on a jock from back east.

Today I speak to you as a witness from Ground Zero of the Biodiversity Crisis. I bring an urgent message.

The human population grows daily, it's on the move, and it's carving a deep technological footprint on this planet. We alter landscapes and perturb ecosystems, inserting ourselves and other species into novel regions of the world, leading to potentially irreversible changes in the biosphere.

This is not news. Half a century ago, Charles Elton, a founder of modern ecology, wrote, "We must make no mistake; we are seeing one of the greatest historical convulsions in the world's fauna and flora."

I was 7 years old when that was written—most of you were not even hypotheses then.

We are also in the midst of an epidemiological crisis. Climate change alters movements and geographic distributions for myriad species. Transporting people and goods carries countless pathogens around the globe. This brings isolated species into sudden contact. Pathogens encounter hosts with no resistance and no time to evolve any.

This is also not news—maladies rare or unknown two or three decades ago, like HIV and Ebola, West Nile Virus and Avian Influenza—have become commonplace. In such a world—this world—events like these are ongoing. Scarcely a week passes without news of some freshly discovered strain of pathogen trading up to a human host.

This is the crisis of Emerging Infectious Disease (EID).

We think of EID as isolated events and react only after the fact. We allocate massive resources to pathogens that have already made themselves known, while ignoring the

far greater threat posed by those waiting in the wings. The ones we know are just the tip of the iceberg—80% to 90% of the world's pathogens haven't been discovered yet. They're discovering us easily enough—weekly outbreaks and endlessly mutating strains of recent years are ample evidence of that. This *succession of crises* is the new *status quo*. They're far better at finding us than we have been at finding them. Why?

The current EID crisis is a new manifestation of an old and repeating phenomenon. The rules have not changed. Every episode of global climate change and ecological perturbation throughout Earth history has produced new pathogens.

More than a million years ago, our African ancestors moved from forest to savanna. Adopting a predatory lifestyle, sharing prey with grassland carnivores, early humans acquired pathogens previously found in hyenas, large cats, and African hunting dogs. They carried those pathogens out of Africa, where they added native hosts in new environments, while native pathogens returned the favor, infecting the newly arrived humans. Agriculture and urbanization brought people and animals into even closer contact, making infection and transmission easier than ever.

In the past 100,000 years, agriculture, domestication, and urbanization disseminated EID risk on a global scale. If doctors had existed in those times, they would have remarked on a worrisome surge in the number of EID, responding to the crisis as best they could, after the fact.

In the past 50 years, exploding human population, rapid transit, and climate change produced the real-time crisis you see on television daily.

The EID crisis is a medical issue in only a superficial sense. It's more fundamentally an evolutionary and ecological issue, a predictable consequence of separated species brought into close contact. The difference today is that human activity accelerates the rate of introductions, so outbreaks occur more frequently and over a wider geographic range than ever before.

The potential for EID is a "built-in feature" of evolution. Research shows that those species best at surviving climate change will be the primary sources of EID. Pathogens are not only good at finding us, they are really good at surviving. Many, not a few, evolutionary "accidents waiting to happen" are out there, requiring only the catalyst of climate change, species introductions, and the intrusion of humans into areas they have never inhabited before.

All of these are happening *right now*.

Today's crisis stems directly from fundamental ignorance about the biosphere: we simply don't know what's out there. And what you don't know can hurt you.

Undiscovered pathogens and their vectors lurk beneath our feet like evolutionary land mines as we move into novel habitats, translocate species, and alter ecosystems. More than 50% of the species on this planet are parasites of some form. They threaten human health, agriculture, natural systems, conservation practices, and the global economy.

I'm not raising the specter of a killer bug wiping out humanity. It's going to be more like death by a thousand cuts. Each EID will exact an economic cost, and even when host immune systems catch up to a particular "new" pathogen, it will not go away. It will persist as *pathogen pollution*. West Nile Virus is no longer an acute problem in North America. But now that it's here, it will always be a chronic problem. Others will follow, each repeating that pattern.

Information about the diversity and distribution of known and potential pathogens is critical for limiting their socioeconomic impacts. Yet, our knowledge of the identities, geographic locations, and threat potential for the world's pathogens can only be called fragmentary. At most, 10% of the world's pathogens have been documented—the rest remain utterly unknown.

This massive ignorance is reason to be concerned about our preparedness to handle the crisis. It's impossible to prepare for a threat whose very existence is unknown. You can't monitor much less seek cures or develop vaccines for undiscovered maladies. We act as if EID is a rare phenomenon and engage in crisis response mode. The evidence is that the potential for EID is large, and climate change will make more of the world accessible to more pathogens.

This makes the planet an evolutionary minefield into which millions of people, not to mention their crops, livestock, and pets, wander daily.

In the near future—if it's not already true—our crisis-response abilities will be overwhelmed.

We need strategic planning based on solving the problem rather than managing it. We must learn the lessons of the past if we are to cope with the future in a timely and economical manner. We need to monitor pathogens so we can assess EID risk before medical or veterinary clinicians see their symptoms. We need evolutionary models that tie together climate change, biodiversity, and EID.

Nothing substantial can be accomplished until we know what we're up against. It's essential that we rapidly complete a global inventory of species. It sounds daunting. But 500,000 years of experience in hunting and gathering; cheaper, faster DNA analysis; and faster, cheaper computers—all these make the task feasible. It's a massive undertaking, but it must be done. It'll be costly, but it'll never be cheaper, and the alternative is to let this chance

slip away, passively accepting the consequences. As Voltaire said, "There is a certain inevitability about inaction."

To be useful in the real world, the information from that inventory must be online. This will require massive societal support for natural history collections and the taxonomic specialists who can identify each species by name, using those names as indices of information. *No name, no information, wrong name, wrong information*. An incorrect diagnosis by a clinician is a taxonomic mistake with devastating consequences. It's as simple and critical as that.

And the database has to grow fast. It's the middle of the fourth quarter and we're 13 points behind. Two touchdowns will do it, but we need focus and a sense of urgency.

The scientific community has contributed to our lethargic efforts. Many scientists, living comfortable lives far from ground zero, see funding opportunities, not crises. Specialization allows us to divide and conquer ourselves. Global climate change is the arena of physicists, geologists, and meteorologists; EID is the province of biotechnology, public and veterinary health specialists; biodiversity is the domain of ecologists and evolutionary biologists. All these phenomena are interrelated and synergistic. We need to be the same—we cannot afford academic business as usual.

Others bear responsibility. The Romans realized that democracy rose and fell on the issue of civilian control of the military—*Quis custodiet ipsos custodes?* Managing a crisis is always more costly than solving it, from the standpoint of those who pay the bills. An equally important question is: Has crisis management become more profitable than problem solving?

Should it bother us that the very people charged with protecting us have an enormous economic vested interest in managing the problem along rather than solving it? We are conditioned to believe in the Medical-Industrial Complex (MIC). And yet, from an evolutionist's perspective, the MIC seems to do everything possible to help natural selection produce strains of pathogens resistant to current pharmaceuticals, leading to the need for more.

Let's do a quick thought experiment: A conscientious mother wipes down the kitchen countertop with a disinfectant after breakfast because TV ads tell her it will kill 99.9% of all germs. If she kills 99.9% of a population of 1 billion germs, 10,010,010 disinfectant-resistant germs survive. At the rate microbes reproduce, by lunchtime they are back to the original 1 billion, but all are resistant to the disinfectant.

And yet, mom does not produce killer germs. Perhaps disinfectant companies do not realize that most of the germs their products destroy are no threat to human health. Next year's new and improved, and slightly more expensive, version will still wipe out 99.9% of germs, but it won't mean anything. Perhaps pharmaceutical companies do not realize there is no necessary connection between a pathogen's ability to resist a drug and its susceptibility to an active human immune system. My recent gastroenteritis took 48 hours to resolve itself without antibiotics, the same amount of time it takes with antibiotics.

I am not suggesting this is deliberate. The MIC simply operates as an entrenched bureaucracy whose relentless application of "best practices" for enhancing the bottom line fuels an evolutionary arms race between pathogens and pharmaceutical companies. The MIC, like all entrenched bureaucracies and their management infrastructures, will resist efforts aimed at fundamental change, even when it is vital to the survival of humanity.

The MIC is likely ignorant of the significance of pathogen evolution. But ignoring the evolutionary basis of the EID crisis is tantamount to mortgaging *your* children's futures.

Evolutionists and ecologists can help biomedical specialists focus their research beams in a timely and cost-effective manner—thereby protecting profits—while moving from being *uninformed-reactive* to being *informed-proactive*. But again, we cannot afford business as usual. Traditional professional boundaries between basic and applied research must come down.

Finally, the public sector. Many politicians and environmentalists in the public spotlight speak as if we need to fix blame before we can begin doing anything. But, as Al Gore notes, it does not matter if climate change is the result of the Industrial Revolution or automobiles or, Ronald Reagan's favorite, trees; what matters is that it is happening.

Nor does it matter whether the current episode will be short or long in geological terms. A short cycle—say, 500 years—is 25 human generations. It might as well be 10,000 years.

No politician wants to be on duty when hard decisions have to be made, so each one works to limit liability, a standard management tactic, rather than to solve problems. Politicians opt for management because their vested interest is limited by election cycles.

Mark Twain had many pieces of advice for politicians. One of them was, "Do the right thing. It will gratify some people and astonish the rest." Society—you—can make politicians aware that unless they do the right thing, they face professional extinction crises. Next election—gratify yourselves, astonish them.

Never change a winning game, always change a losing game. We are playing a losing game. We must stop being victims, believing we can only hang on in a complex world that is largely spinning out of control, at least out of our control. We must begin solving problems, rather than letting them grow slowly but inexorably through the studious application of management principles.

The choice is yours. Don't settle for being problem managers—be problem solvers. See with the clear eyes of youth. Make that clarity count at the ballot box. It may hurt your profit margin in the short term, but your children will surely thank you for it.